ICAL ROOM
L. LIBRARY
OF MICH.

JAN 2 1926

SCIENCE

NEW SERIES
VOL. LXIII, No. 1618

FRIDAY, JANUARY 1, 1926

ANNUAL SUBSCRIPTION, $6.00
SINGLE COPIES, 15 CTS.

Four Good Books

Whetzel's Plant Pathology

Professor Whetzel has given this work a complete revision. Diseases are grouped on the basis of the pathologic phenomena exhibited. At the same time the subgroupings provide for an introduction to the chief groups of etiologic agents. The student is told where to look for the cause and how to interpret what he sees. He is given external symptoms, internal symptoms, and histologic symptoms.

Laboratory Outlines in Plant Pathology. By **H. H. Whetzel, Lex R. Hesler, Chas. T. Gregory, W. Howard Rankin.** Octavo of 231 pages. Cloth, $3.25 net.

Whetzel's History of Phytopathology

Professor Whetzel divides his work into Eras and Periods. He gives a general survey of each Era and each period, crystallizes the evolutionary movement of each; gives interesting biographic sketches of the predominant figures, frequently including portraits, and at the end of each Period adds a concise summary.

History of Phytopathology. By **Herbert Hice Whetzel,** Professor of Plant Pathology at Cornell University, Ithaca. 12mo of 130 pages; 22 portraits. Cloth, $2.00 net.

Smith's Bacterial Diseases of Plants

Professor Smith first gives a synopsis of the study of bacterial diseases of plants, then the methods of research, apparatus, technic of preparation, culture-media, technic of isolation, etc. He then considers in detail 14 organisms—type, cause of disease, technic of isolation, preparation and inoculation; the determination of morphology, histology, signs of disease, variability, transmission, prevention, with a complete bibliography.

Bacterial Diseases of Plants. By **Erwin F. Smith,** Bureau of Plant Industry, U. S. Department of Agriculture, Washington, D. C. Octavo of 688 pages, illustrated. Cloth, $10.00 net.

Fred's Soil Bacteriology

These laboratory exercises are prepared to give *quantitative results* for students of soil bacteriology, chemistry, physics, and plant pathology. You get *practical exercises* on soil micro-organisms, on artificial cultures for legumes, cellulose bacteria, formation of humus in soil, how to sterilize soil, and grow plants free from micro-organisms.

Soil Bacteriology. 12mo of 170 pages, illustrated. By **E. B. Fred, Ph.D.,** Associate Professor of Agricultural Bacteriology, College of Agriculture, University of Wisconsin. Cloth, $1.50 net.

.....SIGN AND MAIL THIS ORDER FORM TODAY.....

W. B. SAUNDERS COMPANY, West Washington Sq., Philadelphia

Please send me the books checked (V) and charge to my account:—

Whetzel's Plant Pathology ..... $3.25 net.
Whetzel's History of Phytopathology.. $2.00 net.
Smith's Bacterial Diseases of Plants.. $10.00 net.
Fred's Soil Bacteriology ..... $1.50 net.

NAME ..... ADDRESS .....

SPECIAL PRE-PUBLICATION OFFER

THE NATIONAL ACADEMY OF SCIENCES and THE NATIONAL RESEARCH COUNCIL of the UNITED STATES

announce the forthcoming publication of

INTERNATIONAL CRITICAL TABLES

of

Numerical Data of Physics, Chemistry and Technology

THE work of compiling International Critical Tables was undertaken by the National Research Council at the request of the International Union of Pure and Applied Chemistry, with the endorsement of the International Union of Pure and Applied Physics, and under the auspices of the International Research Council.

The material contained in International Critical Tables has been collected and critically evaluated by some 300 Co-operating Experts, including chemists, physicists, and engineers of the United States, Canada, Great Britain, Belgium, France, Italy, Austria, Germany, Denmark, Switzerland, Holland, Australia, and Japan.

A world-wide gathering of indispensable data

The scope of the material collected covers all available information of value concerning the physical properties and numerical characteristics of (a) pure substances, (b) mixtures of definite composition, (c) the important classes of industrial materials, (d) many natural materials and products, and (e) selected data for selected bodies or systems, such as the earth and its main physical subdivisions and the solar and stellar systems.

Special limited pre-publication offer

The work will be issued in five volumes, comprising an estimated 2,500 pages (8½ x 11 inches). All volumes will be bound in a uniform reinforced buckram binding, and will be delivered to all advance subscribers as issued, with packing and carriage charges prepaid. In making the publication contract, the National Research Council reserved for scientific men the right to purchase International Critical Tables at a price which represents substantially only the cost of printing and distributing on the following basis:

1. International Critical Tables will be published at the price of $60 for the five-volume set, at which price all orders placed directly with the publishers will be filled.
2. Until the appearance of Volume One (Early in 1926) but not thereafter, the following classes of persons and institutions shall have the right to subscribe at the rate of $35 for the set of five volumes.
   a. Individuals who are members of a recognized scientific or technical society; but only one set may be subscribed for by one individual.
   b. Educational institutions, public libraries, government departments, research laboratories, and the libraries of industries. Such organizations may purchase a number of sets if required for their own use.
3. No orders can be accepted from or through book dealers or agents at the pre-publication price.

NATIONAL RESEARCH COUNCIL

B and 21 Streets, N.W. **Washington, D. C.**

SCIENCE

VOL. LXIII JANUARY 1, 1926 No. 1618

CONTENTS

The American Association for the Advancement of Science:

Some Psychological Experiments: DR. J. MCKEEN CATTELL 1

Oceanographic Investigations of the Scripps Institution for Biological Research: DR. T. WAYLAND VAUGHAN 8

National Research Endowment 10

Scientific Events:

Presentation of the Copley Medal of the Royal Society to Professor Einstein; The Award of Gold Medals by the American Geographical Society; Revision of Educational Methods in the Yale School of Medicine; The 1926 Meeting of the Pacific Division of the American Association 11

Scientific Notes and News 14

University and Educational Notes 17

Discussion and Correspondence:

Projection of Ultra-Violet Lines: PROFESSOR PAUL F. GAEHR. *Influence of Air and Sunshine on the Growth of Trees:* DR. W. J. SPILLMAN. *An Unusual Strain of Serratia Marcescens:* RACHEL SCHREINER and LAETITIA M. SNOW. *The Clearness of the Ohio River:* DR. FREDERICK EHRENFELD 18

Scientific Books:

Williston's Osteology of the Reptiles: DR. C. C. MOOK 20

Special Articles:

The Presence of Sulphate-Reducing Bacteria in Oil Field Waters: PROFESSOR EDSON S. BASTIN 21

The Tennessee Academy of Science: ROSCOE NUNN ... 24

Science News x

SCIENCE: A Weekly Journal devoted to the Advancement of Science, edited by J. McKeen Cattell and published every Friday by

THE SCIENCE PRESS

Lancaster, Pa. Garrison, N. Y.

New York City: Grand Central Terminal.

Annual Subscription, $6.00. Single Copies, 15 Cts.

SCIENCE is the official organ of the American Association for the Advancement of Science. Information regarding membership in the association may be secured from the office of the permanent secretary, in the Smithsonian Institution Building, Washington, D. C.

Entered as second-class matter July 18, 1923, at the Post Office at Lancaster, Pa., under the Act of March 3, 1879.

SOME PSYCHOLOGICAL EXPERIMENTS[1]

IF one of us lifts a hand as soon as a sound is made, the interval elapsing between the sound and the movement will be in the neighborhood of one seventh of a second. This reaction time is measured in thousandths of a second because it is so short and so regular that a very small unit is required. The symbol σ for a thousandth of a second, corresponding to μ for a thousandth of a millimeter, was introduced by me in psychology before it was needed in any physical science. It is evident that in making such measurements psychology is an experimental and an exact science.

During the brief period of the reaction a complicated process takes place. The sense-organ responds in a selective way, the impulse travels along a sensory nerve and perhaps through the spinal cord to lower centers of the brain, then to a higher center, where a selective impulse is formed and is sent back through motor centers and tracts to a muscle that it innervates. The study of these processes and organs—receptors, conductors, reflectors, effectors—belongs primarily to physiology, but any consciousness that may be involved and the total response of the individual are the province of psychology. The sensori-motor arc is a unit; physiology and psychology are as closely interwined as are physics and chemistry in the study of the atom.

The time of reaction varies with the stimulus and the movement, with the condition of the sense-organ and the muscle, with the paths of conduction, with the situation in the nervous centers. Thus the time for a given individual may on the average be 1σ—one thousandth of a second—longer with the left hand than with the right. It may be 20σ longer for light than for sound, a photochemical process in the retina being here involved. It may be 2σ shorter when the intensity of a sound is doubled; thus in so far as there is a logarithmic relation we have the beginnings of a mathematical psychology. The time depends on the condition of the brain centers as related to attention, fatigue and other factors.

As there is no break in continuity between the fertilized ovum and the adult, or, apart from mutations or possible critical points, between the unicellular organism and the highest vertebrate, so

[1] Address of the retiring president of the American Association for the Advancement of Science, given at Kansas City on December 28, 1925.

there is none between the simple reaction and the most complicated human behavior, such as the conquests of Napoleon or the development of the theory of relativity by Einstein. In the practiced reaction there is no consciousness, although the observer plans the response in advance and knows after it is over what the stimulus and the movement have been. In the conduct of daily life we may foresee what we shall do and recognize what we have done; we do not know whether our actions are caused by consciousness or whether consciousness is only a by-product of the activity of the brain. Perhaps it does not make any difference, and is a problem without meaning, as consciousness and conduct would be the same in either case.

The reaction may be made complex under laboratory conditions. Thus instead of reacting to any light, the observer may be required to respond only when the light is red or to lift his right hand when it is red and his left hand when it is green. The average reaction-time with a standard light may be 146σ; the additional time required to make such a discriminative and selective movement may be on the average 194σ. The more nearly alike the stimuli and their associated sensations, the longer is the reaction-time. It thus becomes possible to measure differences in sensations in objective standards, even to determine what difference between two tones is psychologically equal to the difference between two colors.

If one observer can not discriminate as readily as another between red and green, or as he himself can between yellow and blue, the time is longer, and the defect can thus be detected and its amount measured. Inability to see the difference between red and green is the most common form of color blindness, affecting about one man in twenty-five and one woman in a hundred. These are the colors that must be correctly and promptly discriminated in order to secure efficiency and avoid accidents in railway, steamboat and automobile traffic. Color blindness is inherited and permanent; it can not be cured. But we can avoid placing men where the defect is of consequence and we can adjust the colors of signals and in addition to them use shapes, symbols and words that will lessen the danger. It is in general difficult to alter or to improve the individual, but we can select individuals for the work that they can do best and we can make conditions such that the work will be done to the best advantage.

The life of the unicellular amoeba consists largely in reacting to the immediate environment, and this holds through the whole range of animals to our own behavior in daily life. The creature whose responses are prompt and correct, not disturbed by irrelevant conditions and events, is the one that survives and succeeds. There are some 700,000 motor-car accidents annually in the United States, about ninety per cent. of which are due to the human factor. It is a satisfaction to be this year associated with the work of the Highway Safety Conference arranged by the Secretary of Commerce, which is to determine the physical and mental examinations for drivers and public chauffeurs that should be adopted for a uniform system of licenses in the several states and thus to apply laboratory experiments to a useful purpose. Psychological methods are now used for the selection of taxicab drivers in a number of cities with resulting increase in efficiency and decrease in accidents.

When the response is with the organs of speech, both the stimuli and the movements are indefinitely numerous and complex. The words in different languages that can be named are counted by the million. Talking and reading are among the most human of occupations in which a large part of our lives is spent. Their rate measures the length of life more correctly than any calendar, for if one man thinks and acts twice as rapidly as another, he lives twice as long in the same number of years. In speech and reading there is a nice adjustment between the stimulus and the sense organ. We can speak about as rapidly as we can hear—some twenty changes in a second. There appears to be presbyota as well as presbyopia, hardness of hearing in old age being due in part to fusion of successive sounds from loss of elasticity in the organ. Fusion in the eye, as is well known, is at nearly the same rate, and we get it in the movies when the pictures are superimposed at the rate of sixteen a second. Though we are familiar with the distortion of sound waves, the blurring in hearing from fusion in the sense organ has not hitherto been considered.

We can recognize a color, an object or a picture more quickly than a word, but we can name a series of words about twice as quickly as a series of colors or pictures. Young children and uneducated people, however, can name the colors or the pictures the more readily. Reading, like the simple reaction, is an acquired reflex; it is possible to read aloud with proper emphasis without attention to the words or the meaning. Education and training consist largely in forming correct automatic responses to usual situations, thus largely eliminating effort and fatigue and allowing freedom for other activities.

It takes in the neighborhood of half a second to see and name a word, the time being slightly shorter for a whole word than for a single letter. We read words as wholes, and the child should learn to read in that way. Each of a series of unrelated words in view at the same time can be read aloud about twice

as quickly as a single word, and words making sentences can be read about four times as quickly. In these cases the processes overlap in time and form larger units both of the stimuli and of the movements. Words in context can be read as rapidly as the speech organs can be moved—up to about seven a second. By inexperienced readers and in foreign languages such units can not be formed so readily. For example, in reading aloud as rapidly as possible, the rate per word in thousandths of a second of an observer was: English 138, French 187, German 250, Italian 327, Latin 434, Greek 484. This is a good way to measure a student's ability in reading or his familiarity with a foreign language.

If a series of letters or words is shown so that two or more are in view at the same time, they can be read more rapidly than if they are presented singly. The speed increases until, according to the individual, three to five letters are in view at once. There is thus measured the complexity of the impression that can be grasped at one time or the range of consciousness. Similar results are obtained when objects are presented simultaneously to the eyes for the hundredth of a second, a time too short to permit of successive apprehension. An observer may be able to perceive a maximum of three or four unrelated letters, two or three words or a sentence of four or five words. He can thus perceive and remember some five times as many letters when they form words and sentences as when they are disconnected. Normal individuals with comparable training were found to differ within a range of about two to one. Men engaged in manual work were much inferior. There was no difference between those speaking English and German; women were slightly superior to men. The age factor was considered and also the application to pathological conditions.

These experiments, published in 1885, were the first measurements of individual differences in psychology and in connection with them the term individual difference was apparently used for the first time. The term mental tests, which also has become an international word, was used by me a little later. Certainly individual differences have been recognized from the beginning—to be a fundamentalist for the moment—from the sex differences between Adam and Eve, and the character differences between Cain and Abel. The four temperaments defined by Galen—choleric, sanguine, melancholic and phlegmatic—have some validity. The Darwinian doctrine of variation and survival brought the whole subject into the field of distinct vision; we owe its earliest scientific development to Francis Galton, who was Darwin's cousin.

The most important work for psychology and its most useful applications are the measurement of individual, group and racial differences, and the determination of the extent to which these depend on native endowment and on subsequent experience. Indeed it is arguable that this is the most pressing problem of science and of society. If each of us from the moron to the federal president were selected for the work that he can do best, the work fitted in the best way to the individual and the best training given to him, the productivity of the nation would be more than doubled and the happiness of each would be correspondingly increased. If the best children were born, and only they, the welfare of the world would be advanced beyond the reach of practical imagination. Truly the harvest is large, but the psychologists are few. As I said in 1896 in my presidential address before the recently established American Psychological Association: "We not only hold the clay in our hands to mould to honor or dishonor, but we also have the ultimate decision as to what material we shall use. The physicist can turn his pig-iron into steel, and so can we ours; but he can not alter the quantities of gold and iron in his world, whereas we can in ours. Our responsibility is indeed very great."

When in the experiments described we determine the time that an object must be in view in order that it may be seen, it is found to be in the neighborhood of 1σ comparable to the time that a sensitive photographic plate must be exposed. It varies with the intensity and area of the light, as well as with the color and with the complexity of the object, thus permitting us to use in psychology the equations of physical science relating to time, energy and the configuration of a system. The time of exposure necessary for vision tends to vary as the logarithm of the intensity of the stimulus. Differing from the photographic plate, the retina is most sensitive to yellow. The total times are so short and regular that it is necessary to measure them to the ten thousandth of a second. The time is as short for words as for letters, it is longer for German than for Latin letters, it varies with the letter.

This method is of practical interest because it enables us to measure the legibility of types and letters. "E" was found to be the most illegible of the capitals, "s" of the small letters, and these are the ones most frequently used. They are hard to see because the field is divided into two parts. Other letters are hard to discriminate owing to their similarity, as the group i, l, f, t, which we continually mistake the one for the other. It might be possible to put λ in place of l, and the dot should be left off i as in Greek. It is foolish in printing to use ink and lead to strain the eye and brain. The Greek Δ is a legible form that we ignore. Our letters have been handed down from

the past, like much else in our civilization, and should be adjusted to meet modern conditions. They were developed largely for ease in writing, whereas since the invention of the printing press we are concerned only with ease in reading. Punctuation marks are hard to see. If in printing, spaces were left equal to the pauses in reading and the normal rate of understanding, reading would be easier, and writing and printing would become more of a fine art. The short lines developed by the newspaper are easier to read than the long lines of books, and it would save fatigue if the lines were not adjusted to make them exactly fill the space, as the moving eye could then more readily follow the text.

In some of these experiments the object moved over the stationary eye. If one of us looks through a window one centimeter square, and behind it three white centimeter squares separated by black centimeter spaces are passed, one square is not seen after the other, but the three squares are seen side by side, somewhat crowded together and blurred, but two or three times as large as the window through which they are seen. If in this way red is exhibited followed by green, red is not seen first and then green, but usually red, white and green together, covering a field several times as large as the retinal image. We perceive as a spatial continuum what is a time series in the physical world, in the incoming nervous impulse and in the brain centers.

In these cases each perceives the same physical stimulus in his own way. He may see the green above the red, the green within the red, or conversely, bars of red and green arranged vertically or horizontally, etc. The first time that a stimulus is presented to an observer, he ordinarily has only a vague perception. The same stimulus after several trials gives a clear perception, which thereafter tends to remain the same for the same observer, though likely to be very different for different observers. When the actual physical stimulus is known, some observers see it as before, others quite differently. The attitude of the observer is as integral a part of perceptions as the incoming nervous currents, and perceptions are prescribed by reactions. For an infant the visual world must be a chaos which he learns to see in the way useful for his motor reactions. Objects are seen erect whatever the position of the image on the retina and one object is seen with two retinal images.

Prior to these laboratory experiments it had not been remarked that in the vision of daily life objects are presented to the eye one after another, but are perceived side by side. As a person looks about the room, first one object and then another falls on the area of distinct vision, but he sees the objects, not one after another in the same place, but side by side in the spatial arrangement in which he would find them, and covering a field which it is impossible to see simultaneously. That in daily life we see a time order as extension in space would be as subversive to our commonsense notions as the theory of relativity if we were not in the habit of regarding the physical world as fixed and mental life as lawless.

As the difference between two stimuli is made smaller, the time of discriminative reaction becomes longer, and we reach the degree of likeness at which the response is indefinitely delayed, or if made is as likely to be wrong as right. The least noticeable difference and its relation to the intensity of the stimulus have been the subject of many laboratory measurements and of much theoretical discussion. The Weber-Fechner law was anticipated for lights by Bouger and Lambert and in general application by Laplace when he said that the *fortune moral* is equal to the logarithm of the *fortune physique*. This equation in fact only formulates a deduction from tithes and most systems of taxation, and the common attitude, as illustrated in the story of the widow's mite. Psychological relativity, which has but little to do with modern theories of physical relativity, is of wide application. For example, if the satisfaction purchased by wealth increases as the logarithm of the wealth or indeed more slowly than in direct proportion, then the maximum welfare in consumption is secured by an equal distribution of wealth. When the Greeks spoke of the envy of the gods, they had in mind the relativity of pleasure and pain, of success and failure.

Many thousands of measurements on the perception of small differences have led me to question the meaning of a just noticeable difference and its use as a unit to measure the intensity of sensation. We seem to be concerned with the errors of observation known to astronomers and other students of the physical sciences. There is no difference that can just be perceived, but the percentage of errors becomes greater as the difference is decreased. When the observer is right in 75 per cent. of the trials, the difference between the stimuli is the probable error, when he is right in about 84 per cent. it is the error of mean square. When one stimulus is made as nearly as possible like another, a method that can be used to special advantage with movements, we get the average error. The algebraic sum of normal errors increases as the square root of the number, and in so far as a magnitude is composed of units that are independently judged, the error of observation or just noticeable difference should increase as the square root of the magnitude. As Professor Woodworth has pointed out, if such errors were correlated the resulting error would increase more rapidly up to direct proportion, as re-

quired by Weber's law. Experimental data fall within these limits, the relative threshold being larger for small and for large stimuli.

These considerations are technical, but have wide application in photometry, in the practice of the aurist and in many other directions. An object may be a thousand times as brightly illuminated at one time as another, a speaker's voice may be a thousand times as loud near by as at a distance, but it is the same object and the same voice, and we want to perceive them as the same, so are concerned with relative rather than with absolute differences. When a friend approaches to shake hands from a distance of six feet to three, the image on the retina becomes twice as large, but we see no change in the size of the face. It is hard to realize that the little finger will cover the moon or that from a more distant seat at the opera the face of a singer is smaller than the head of a pin held in the hand. The relativity of sensation and the measurement of the intensity of sensation are in the penumbra of the field of experimental psychology, but we have clear light on the accuracy of perception under different conditions and on individual differences in discrimination.

A difference in illumination of one hundredth or less is perceptible, and vision is regarded as the most acute of the senses. The stimuli are, however, compared both simultaneously and in succession a number of times, and the conditions are not the same as with other senses. When illuminated areas were shown in succession, each lasting one second and one second apart, the probable error for different observers was from 9.9 to 18.7 per cent. of the stimulus, the sense of sight being about half as accurate as the sense of movement. In lifting weights of 100 grams the average probable error of 10 observers was 6.2, and a difference of 21 grams should be correctly discriminated 99 times out of a hundred trials. The extent of movements can be judged better than the force and the force better than the time. Normal individuals vary in accuracy of perception within a range of about two to one, which is the variability in the duration of the sensori-motor responses.

The reaction may be made to include an association or an act of memory by continuous gradation. Thus one observer required on the average 149σ longer to name pictures of objects in German than in English, 152σ to translate familiar German words into English, 258σ in the reverse direction. It took 350σ to recall the language in which an author wrote, 462σ the country in which a city is situated, 336σ to add numerals, 544σ to multiply them. It takes less time to add 2 to 3 than to add 6 to 7, or than to multiply 2 by 3. When more than one response is possible, the process becomes more difficult; it takes about a fifth of a second longer to name some author who used a given language than to name the language in which a given author wrote. Still larger range of response may be allowed. Thus there was measured the time it takes to give an example of a class of objects, to name part of an object either presented as a picture or a word, to give the property of a given substantive or the substantive that goes with a given adjective, an object for a transitive verb or a subject for an intransitive verb. These experiments are the basis of the completion tests applied by Ebbinghaus to school children and now extensively used in our intelligence tests.

It is also possible to measure the time of a decision or judgment. Thus the observer referred to required on the average 644σ to estimate the length of a line, 558σ to decide which of two eminent men he regarded as the greater. The individual difference in the nature of the association and the time required throws light both on native equipment and on acquired interests. A teacher of mathematics could remember that $5+7=12$, a student of literature that Dante was a poet, in about a tenth of a second less than another. In describing these measurements in 1887 it was remarked: "Such experiments lay bare the mental life in a way that is startling and not always gratifying."

This may be reminiscent of psychoanalysis concerning which psychologists differ. Formerly a casual acquaintance who learned that he was speaking to a psychologist most frequently inquired about what goes under the name of psychical research—mediums, spirits, ghosts, clairvoyance, telepathy and the rest—often continuing with his own remarkable experiences. Now psychoanalysis is the more usual topic for such after-dinner conversations. Perhaps it need only be said here that witches in New England were convicted on better evidence than can now be adduced for any supernormal events, that miracles at Lourdes are better attested than any of the queer experiences of Sir Oliver Lodge or Sir Conan Doyle. Psychoanalysis is not so much a question of science as a matter of taste, Dr. Freud being an artist who lives in the fairyland of dreams among the ogres of perverted sex. In reference to applied hypnotism, suggestion and psychoanalysis, the remark attributed to Franklin may be repeated: "There is a great deal of difference between a good physician and a poor physician, but not much difference between a good physician and no physician."

Galton in England and Wundt in Germany initiated studies of association when one word or idea suggests another. In 1889 I published the results of some 15,000 measurements of the time of such associations together with classifications and correlations. These

were the first of the psychological measurements of school children which have now been found so useful that some three million tests were made last year in our public schools. The experiments of forty years ago also have a certain interest because American, English, Irish and German students were tested in their native schools, and we thus have a beginning of racial comparisons of which there is urgent need at the present time in view of their practical application to immigration and other social problems of national importance. We have as yet scant scientific knowledge of the differences between the sexes or among races, family stocks, social classes or occupational groups, and of the directions in which by native endowment or by habits, traditions and institutions, one is different from or superior to another.

In these experiments on association it was found from 363 students in a London school that the time of the total process decreased from 11.76 seconds in the third form, where the children were of the average age of 12.7 years, to 4.13 seconds in the fourth form, where the average age was 17.8 years. There was a positive but small correlation between the tests and class rank, and it was remarked: "It is possible that such experiments measure the alertness of the student's mind more accurately than does the class-rank." This is indeed the fundamentally important aspect of the intelligence tests now used for entrance to college and in many other directions. The psychologist wants to tell what a man can do rather than what he has learned, what use he will make of opportunity rather than what advantages and privileges he has had. The intelligence tests used by psychologists with 1,800,000 conscripts during the war proved most useful in selecting the officer material at the upper end of the curve of distribution, in eliminating those unfit even for the ranks at the lower end. We may look to a great extension of these tests in industry, as soon as they are adjusted more exactly to the conditions, and employers learn their economic value.

In experiments on association we are concerned with the character as well as with the time of the process. The association may be primarily of objects given together in the physical world or it may be due to rehandling by inner experience. Thus it was found that persons engaged in teaching and writing had a larger proportion of logical and verbal associations than others. The Irish students had a larger proportion of these than the English students; the students in a German Gymnasium, where the languages were their main occupation, a still larger proportion of verbal associations. Anecdotes concerning association and the making of categories and classifications have been an occupation of psychologists from Aristotle to the present time. In the paper referred to, statistical methods were used to classify thousands of recorded associations, but it was noted that it was extremely difficult to observe by introspection the process of association, whether in the usual course of mental life or in such experiments. Determinations of free associations are used in psychiatry and in the detection of crime. But in the various types of intelligence tests, it is not the character of the associations, but the time measurements and the correctness of the answers that have proved useful.

Associations and trains of ideas are supposed to be given in terms of the senses. The studies by Fechner and Galton of mental imagery by the questionnaire method were its first use in classifying individuals. Great differences were reported in the clearness and brightness of the images; people have been divided into visuals, audiles, motiles and tactiles. Imagery was one of the original series of tests made on the students of Columbia University in the early nineties, and doctorate dissertations by Dr. Lay and Dr. Betts contain extensive experimental investigations. It appears that people are not competent to describe the train of their ideas and that indirect methods show the comparative unimportance of imagery, which may be only a surface sensory coloring. From tests on Pillsbury, who played twenty games of chess without seeing the boards, it was found that he did not depend on mental images, but on the histories of the games. The situation is different with so-called motor images, for these are really incipient movements and can be measured in the laboratory. All stimuli tend to discharge movements and it seems that one of the principal differences between ideas or images and perceptions is the larger motor element in the latter which gives them what Hume called their "force and liveliness."

There are certainly dreams and hallucinations, and in ordinary perception more of what we seem to perceive is supplied by the central nervous system as molded by past experience than by the incoming currents. Memory images of various kinds and entoptic phenomena form nearly a continuum between imagination and perception. An after-image impressed on the retina or brain twenty years ago is still visible; this may seem incredible, but Newton acquired an after-image that lasted three years. The duration and character of the after-image as well as its color and oscillations were correlated by Dr. Franz with the quality, duration, intensity and area of the stimulus. There are significant individual differences which may denote ability in observation and power of attention.

Ordinary observation, recollection and general information are more defective than is commonly supposed, and this is particularly the case when the per-

son at the time of an event does not know that he will be called upon to describe what has happened. An attorney can discredit a witness by asking questions to which a correct answer should not be expected. As a result of a study published in 1896, it was found that when students in a psychological class were asked—being allowed thirty seconds for reply—what the weather was a week ago the answers were: clear 16, rain 12, snow 7, stormy 9, cloudy 6 and partly stormy and partly clear 6, about the probable distribution of weather at the beginning of March. When asked which way the seeds in an apple point, 24 said upward, 18 towards center, 13 downward and 3 outward. Answers as to the date of Victor Hugo's death ranged from 1790 to one maintaining that he was still living. Estimates of a given period of 35 seconds ranged from 5 to 150 seconds. When the students were asked what was said during the first two minutes of the lecture in the same course given one week before, the accounts were such that the lecturer might prefer not to have them recorded. From the testimony of the students, it would appear that two minutes sufficed to cover a large range of psychological and other subjects, and to make many statements of an extraordinary character. Similar experiments were made on classes in the Horace Mann School, and these were among the first psychological experiments made on school children.

Practice, learning, memory and fatigue can to great advantage be made the subjects of objective and quantitative psychological experiments. Ebbinghaus's monograph on the learning and recall of non-sense syllables (1885) and the study of the practise curve in learning the telegraphic language by Bryan and Harter (1897) are the classical foundations in these fields. The first practise curve was, however, made in 1886–7, by running daily three miles and plotting the decreasing times and rate of the heart. These also antedated Mosso's experiments on muscular fatigue, on which and its relation to mental conditions many experiments have been made.[2]

[2] The substitution of a spring for a lifted weight in experiments on fatigue, a dynamometer for the thumb and forefinger to replace the whole hand, instruments for adding successive pressures of the fingers and hand so that fatigue and practise curves can be obtained without a kymograph, and an algometer to measure the pressure causing pain, as also the substitution of the Kelvin syphon, pen, pencil and typewriter ribbon for a smoked surface on the kymograph, and a continuous kymograph in which the paper was smoked and the record was fixed automatically as the records were made, appear to be useful technical devices. In this connection may be mentioned also a smoked plate glass disk as a chronograph, enabling us to project fatigue curves, reaction times, involuntary movements in response to a stimulus, the psychogalvanic reflex, etc., on the screen before a class or a large audience. These instruments are mentioned here to emphasize the fact that psychology is an experimental science and that a workshop is a desirable part of every laboratory.

How we learn, the best way to learn, the right age at which to learn different things, the transfer of learning from one field to another, are subjects of fundamental importance in psychology and in education. Making practise curves is itself an excellent educational method. The child learns more by working as hard as he can for a short time than by dawdling for a couple of hours. When he plots the curve he is anxious to improve each day's record and the objectively measured competition is with himself as well as with others. Thus it was found that if a boy of ten writes on the typewriter by proper methods twenty minutes a day for sixty days and plots the curves of the amount accomplished and of the errors, he learns to write faster than any one can write by hand. In the meanwhile he learns to spell and to correct his mistakes; he learns arithmetic and geometry as realities; he learns the value of measurement and objective standards. Practise and learning experiments, including records on each of 365 consecutive days, have been made by me for forty years and are now being made. Whatever the scientific value may be, it adds to the interest to keep practise curves in chess, cards, billiards, tennis and the like.

Daily, weekly and seasonal curves; the optimum periods for definite tasks and for a day's work; industrial fatigue; temperature, ventilation and humidity; the most desirable sexual relations, food, amount and distribution of sleep; rest, play and physical exercise; the use and misuse of emotional excitement and of drugs as sedatives and stimuli: these have been the subject of many investigations in the Columbia laboratory. There are none more important in their practical application to the affairs of daily life. The human psycho-physical organism has through long ages by natural selection or otherwise adjusted itself to the world in which it lives. It was not adapted to the innumerable new demands of modern civilization. It has proved itself plastic to an extraordinary degree, but it is the business of psychology to obtain scientific knowledge of the whole situation and then to apply it for the benefit of all.

The Taylor system initiated a new profession of psychological and industrial engineering. It has been retarded because trade unions, not without reason, feared speeding-up methods. A long correspondence with Mr. Gompers shortly before his death indicates that the unions may ultimately in their own interest take up questions of the psychological selection of men and the improvement of the methods of their

work. The British Institute of Psychology has been successful in securing the cooperation of the workers and has in some directions increased production by 40 per cent. with decreased fatigue. In every field of activity from the use of pick and shovel, of typewriter and ledger, through the factory and office, to the organization of the work of the executive or the congress of the nation, investigations might be made which if put into effect would add from 10 to 100 per cent. to effective productivity and lessen to an equal extent effort and fatigue.

It is absurd that researches whose economic value can only be told in billions of dollars and whose contribution to human welfare is even more immeasurable should await the pleasure of a few academic psychologists who take them up in the intervals between coaching the members of a junior social and athletic club and helping with the family housework, and then only until they get into difficulties with the president or themselves become presidents. In our competitive and capitalistic system services to an individual or corporation are paid for, often to excess, whereas services to society are paid for only in the fiat currency of reputation, titles, degrees and the like. A surgeon may receive a thousand or ten thousand dollars for saving or killing his patient. If after years of research he should discover a cure or prevention of appendicitis or cancer, he not only would not be paid for his work, but would lose all future fees. The psychologists of the country, as is becoming for those directly engaged in the study of human behavior, have taken the lead in forming a Psychological Corporation whose objects are to conserve for research part of the profits from the applications of our science and to conduct new research on an economic basis. Scientific men should take the place that is theirs as masters of the modern world.

J. MCKEEN CATTELL

(To be concluded)

OCEANOGRAPHIC INVESTIGATIONS OF THE SCRIPPS INSTITUTION FOR BIOLOGICAL RESEARCH OF THE UNIVERSITY OF CALIFORNIA[1]

1. Prior to the retirement of the former director, Dr. Wm. E. Ritter, it was decided to convert the Scripps Institution from one for biological research into an institution of oceanography. With one exception all of the researches at present prosecuted at the institution have to do either directly or indirectly with the ocean.

2. The oceanographic work of the institution is divided into four categories, since some kind of subdivision is necessary. The subdivisions are geological, physical, chemical and biological oceanography. Each of the investigations included under the categories enumerated is in charge of one or more men of recognized research ability.

3. Investigations such as those on the ocean are logically divisible into three steps. The first consists in making observations and collecting material for laboratory study; the second, in the laboratory study of the data and collections and the preparation of reports for publication, and the third, in publication. At the Scripps Institution moderate provisions have been made for the first and second steps and consideration is now being given to the problem of publication.

4. The Scripps Institution has in operation, partly through its own efforts and partly through arrangements for cooperation, an extensive plan for obtaining oceanographic and meteorologic data and plankton, water and bottom samples from the Northeast Pacific.

During a part of each year the institution has operated along and off the coast of southern California a small boat either owned or charted by it. It maintains a number of shore observing stations along the west coast of the United States from the latitude of San Diego to the mouth of the Columbia River. Several of these stations are maintained through cooperation with the United States Bureau of Lighthouses; and one at Pacific Grove, through cooperation with the Hopkins Marine Laboratory.

The vessels of the United States Coast and Geodetic Survey operating off the west coast of the United States, between the United States and Alaska, and in Alaskan waters obtain for the institution both hydrographic and meteorologic records and extensive series of water, plankton and bottom samples. In many places the vessels of the Coast and Geodetic Survey have made vertical sections of the water from the surface to the bottom and now sufficient data have been accumulated for preliminary calculations of oceanic circulation off the west coast of the United States according to methods devised by V. Bjerknes.

By an arrangement with the United States Navy, meteorologic and hydrographic records and water and plankton samples are being obtained for the institution by the destroyer fleet under the command of Rear Admiral Frank H. Schofield between San Diego and the Guadalupe Islands; between San Diego and San Francisco; between San Francisco and the Hawaiian Islands, where the destroyer fleet will divide; between the Hawaiian Islands and San Diego by that part of the destroyer fleet which will return directly to San Diego, and between the Hawaiian Islands and Australia and return by that part of the fleet which will

[1] Abstract of a paper presented before the section of oceanography of the American Geophysical Union, Washington, D. C., April, 1925.

make that voyage. Before the vessels started on the voyage all the thermometers used by them were calibrated or provisions were made for subsequent calibration by the Scripps Institution. The arrangements above indicated will give virtually a complete survey of the surface oceanic conditions along all the routes over which the battle fleet will operate during 1925.

The Southern California Edison Company, the Los Angeles Bureau of Light and Power and the Southern Sierras Power Company have combined to aid the Scripps Institution in its studies of ocean temperatures, and the organizations enumerated have contributed a fund for the purchase of two thermographs, one of which will be installed on the pier of the Scripps Institution and the other at Balboa. An arrangement has also been made with the sanitation engineers of Los Angeles for a detailed study of the effect of sewage on sea water in the vicinity of San Pedro, California.

Upon the initiative of the commandant of the Naval Air Station at San Diego an arrangement has been made for the study of the fog problems along the coast of southern California by the officers of the Naval Air Station, the United States Weather Bureau and the Scripps Institution.

The United States Coast and Geodetic Survey has established on the pier of the institution one of its automatic tide gauges and Dr. G. F. McEwen has been appointed tide observer of that bureau.

An arrangement has been made with the committee on seismology of the Carnegie Institution of Washington for the installation of three seismographs, one for each component, on piers erected in the basement of the Museum-Library building of the Scripps Institution. The seismographs will be contributed by the committee on seismology of the Carnegie Institution of Washington, while the piers have been erected by the Scripps Institution. The instruments will be cared for by members of the staff of the institution but the records will be turned over to the seismologists of the committee on seismology.

The geologic aspect of the work in oceanography comprises cooperation in the study of seismology in southern California and the investigation of marine bottom deposits. During the past year some progress has been made in the study of marine sediments. Large collections of bottom deposits from off the west coast of the United States have been assembled at the institution. It is hoped that these collections will grow and that it will soon be possible to present a new map of the marine bottom deposits of the Northeast Pacific.

The investigations in dynamical oceanography are in charge of Dr. G. F. McEwen. During the past year the salinity has been determined for some thousands of water samples received from a number of different sources. The data on temperature, salinity, and other physical features of sea water are systematically filed. The purpose of acquiring the data of the kind above indicated is to interpret the general physical conditions of the sea and particularly to solve problems of oceanic circulation. Dr. McEwen has now about ready for press a paper entitled "A mathematical theory of the temperature distribution in water due to solar radiation, evaporation and convection." Very shortly it is intended to undertake preliminary computations of the oceanic circulation in the eastern North Pacific; and Dr. McEwen has in preparation a summary of the physical oecanography for the Northeast Pacific from the years 1916 to 1925, inclusive, which should be ready for press during the latter part of 1926. Investigation of the interrelation between oceanic conditions and the rainfall in the Western United States is being continued.

The chemical investigations of the Institution are in charge of Dr. E. G. Moberg. These investigations comprise analysis of plankton per unit volume of water, with particular reference to its relative food value, and the variation in amount and the chemical features of the plankton according to season, depth and a number of other factors; the determination of the hydrogen ion concentration of sea water and the relation between the variation of the hydrogen ion concentration and a number of factors; the determination of nitrogen compounds in sea water; the determination of the amount of phosphate in sea water; and the relation of the run-off from the land to the chemical constituents of sea water. Dr. Moberg has just completed a summary of the chemical work he has done during the past four years and his paper will soon be submitted for publication. It is intended within a short time to undertake detailed chemical analysis of the ash of plankton in order to find out what contribution decaying plankton may make to marine bottom deposits, and to undertake certain work on chemical composition of the organic material associated with bottom deposits.

The biological investigations conducted by the staff of the Institution have been mostly confined to the quantitative study of plankton organisms per unit volume of water and the variation in the composition of the amount of plankton according to a number of factors, such as season, temperature of the water, depth, distance from the shore, hydrogen ion concentration and other factors. Professor W. E. Allen has for a number of years investigated the diatoms and dinoflagellates from the standpoint indicated and has already published many papers, and he has a number of papers either ready or almost ready for press. The number of plankton samples received by the in-

stitution is enormous and one of the most pressing needs of the institution is to obtain additional assistance in the study of the collections already on hand and being received from a number of sources. The results already obtained indicate that light is being thrown on a number of important marine problems by systematic and continued investigations along the lines now being pursued. Professor C. O. Esterly is making investigations of the copepod fauna along and off the coast of southern California in a way similar to the investigations conducted by Professor Allen on the diatoms and dinoflagellates, and has published a number of papers. Recently an arrangement has been made with Dr. J. A. Cushman for a systematic study of the foraminifera along and off the coast of southern California.

The institution helps numbers of marine biologists by offering them facilities for studies at the institution and by supplying material to investigators. In an abstract such as this, it is not practicable to enumerate persons of the two categories indicated who have profited by such facilities as the institution can afford. It is desired that these facilities be utilized up to the institution's capacity.

During the coming summer it is proposed to hold at the Scripps Institution two conferences. The first of these will deal with the physical oceanography and meteorology of the Northeast Pacific and the interrelations of oceanic phenomena with the climate of the western United States. It is hoped to have represented at this conference all those institutions and organizations interested in such matters. It is intended that the second conference shall deal with certain problems of bacteriology, biochemistry and physical chemistry of the sea, and their relation to certain geological processes.

T. WAYLAND VAUGHAN

SCRIPPS INSTITUTION

NATIONAL RESEARCH ENDOWMENT

THERE was noted in SCIENCE last week the plans for a large endowment to establish national research professorships and to promote research in other ways under the auspices of the National Academy of Sciences. The official text of the announcement follows:

The National Academy of Sciences has appealed to a body of prominent public men to join with leading scientists in an endeavor to secure larger resources for research in pure science. It is hoped that an annual income of at least two million dollars can be secured to establish National Research Professorships and in other ways to cooperate with universities and other institutions throughout the country which are prepared to do their full share in the encouragement and support of fundamental research in the mathematical, physical and biological sciences. While the United States is in the forefront of industrial research, it is accomplishing much less in pure science than its population and material resources would lead one to expect.

The academy has created a special board of trustees of the National Research Endowment which includes Dr. Albert A. Michelson, president of the National Academy of Sciences; Gano Dunn, chairman of the National Research Council; Dr. Vernon Kellogg, permanent secretary of the National Research Council; Elihu Root, Herbert Hoover, Andrew W. Mellon, Charles E. Hughes, John W. Davis, Julius Rosenwald, Colonel Edward M. House, Cameron Forbes, Felix Warburg, Henry S. Pritchett; Dr. Robert A. Millikan, foreign secretary of the National Academy of Sciences; Dr. John C. Merriam, president of the Carnegie Institution of Washington; Owen D. Young and Henry M. Robinson; Dr. Simon Flexner, director of the Rockefeller Institute for Medical Research; Dr. John J. Carty, vice-president of the American Telephone and Telegraph Company; Dr. William H. Welch, director of the School of Hygiene and Public Health of Johns Hopkins University; Dr. James H. Breasted, director of the Oriental Institute of the University of Chicago; Professor L. R. Jones, of the University of Wisconsin; Professor A. B. Lamb, director of the chemical laboratory of Harvard University; Professor Oswald Veblen, of Princeton University; Dr. Thomas H. Morgan, of Columbia University, and Dr. George E. Hale, of the Mount Wilson Observatory. Mr. Hoover has been requested to act as chairman of the board and has accepted.

In discussing the vital need for greater financial support of pure science research, Mr. Hoover said in a recent address:

> While we have in recent years developed our industrial research upon a scale hitherto unparalleled in history, we have by no means kept pace in the development of research in pure science. The sudden growth of industrial research laboratories has in itself endangered pure science research by drafting the personnel of pure science into their ranks. Thus applied science itself will dry up unless we maintain the sources of pure science. We must add to knowledge, both for the intellectual and spiritual satisfaction that comes from widening the range of human understanding, and for the direct practical utilization of these fundamental discoveries. A special study in an industrial laboratory, resulting in the improvement of some machine or process, is of great value to the world. But the discovery of a law of nature, applicable in thousands of instances and forming a permanent and ever available addition to knowledge, is a far greater advance.

Elihu Root is no less emphatic than Herbert Hoover in his appreciation of fundamental scientific research. He says:

Every practical advantage gained in utilizing natural forces for the benefit of mankind can be traced back to a necessary basis established through fundamental research in pure science by men who had no other object than to ascertain the truth. If that kind of research ends progress in applied science must presently also end. Fundamental research requires systematic support because it does not present the manifest promise of immediate profits. I think the proposed organization for the purpose of securing such support is very important and will be of the greatest value. I am much gratified that Mr. Hoover is willing to give his great ability and prestige to making the new undertaking a success.

Judging from our progress in other fields, we do not lack competent men for research, officials of the academy explain. Too often, with the comfort of their families at heart, such men reluctantly accept well-paid industrial positions instead of poorly paid academic posts. The problem is to make these posts so attractive that the ablest men will seek and hold them permanently because of the opportunities they offer to advance knowledge by fundamental research. This can be done by providing adequate salaries, freedom from too much teaching or administration, necessary instruments and apparatus and skilled assistants to perform the extensive routine operations that scientific research involves. In short, able investigators should be given some such comfort in life, freedom of action and opportunity for constructive thought that industrial and administrative officers in this country, certainly of no larger calibre, habitually enjoy. One way to accomplish this is by establishing National Research Professorships, or similar positions, in cooperation with universities vitally interested in the advancement of science. One hundred National Research Fellowships, financed by the Rockefeller Foundation and the General Education Board, are bringing the best advanced students in the physical and biological sciences and in medicine into research. The next important step is to improve the academic conditions under which such men, and more especially the mature investigators of demonstrated success, conduct their work.

President Michelson, of the National Academy, in writing to Mr. Hoover to express his great satisfaction that he had undertaken to act as chairman of the trustees of the National Research Endowment, says:

I regard this as one of the most important and significant movements in the direction of helping to make the contributions to science worthy of the enterprise of America.

We can no longer plead youth and the pressure of building up the industries as an excuse for the unfavorable comparison of our own meager contributions with those of England, France and Germany. There can be no doubt that the situation would be immensely improved if the prospects of the more promising men who have the talent and ability and the taste for the pursuit of scientific investigation could be made comparable with those of say a successful physician or lawyer.

There is not the slightest conflict between the purposes of the National Academy of Sciences and those of the Smithsonian Institution, which is seeking a large endowment fund to provide adequately for the important investigations of its large staff. These two scientific organizations enjoy most cordial relations, as Mr. Hoover indicated in his recent New York address when he strongly commended the efforts of the Smithsonian to obtain an endowment and referred to it as the great pioneer of all American research, which has inspired much of the work in progress to-day.

Dr. Robert A. Millikan writes as follows:

In the application of science to industry the United States has always taken a leading place among the nations, and our industries may be counted upon to see that she continues to do so. But no such claim to leadership in the field of fundamental science can as yet be made for her. For the sake of our own intellectual development, for the sake of the diffusion of the spirit and the method of science among her people, and for the sake of the future of her material progress as well—fundamental science of to-day being but the applied science of tomorrow—her supreme need just now is for the stimulation of research in the fundamental sciences throughout the length and breadth of the land. This is why I regard the attempt to establish a National Research Endowment for the above purpose as one of the most important national movements ever launched in the United States.

SCIENTIFIC EVENTS

PRESENTATION OF THE COPLEY MEDAL OF THE ROYAL SOCIETY TO PROFESSOR EINSTEIN

PRESENTATION of the Royal Society medals was made at the anniversary meeting of the society on November 30, by the retiring president, Sir Charles Sherrington. The following citation was made with the award of the Copley Medal to Professor Albert Einstein:

The name of Einstein is known to every one through the theory of relativity which he originated in 1905 and extended by a notable generalization in 1915. Einstein realized that the time and space with which we are so directly acquainted by experience can be no other than the fictitious *local* time and space of the moving system—the motion in this case being that of the earth; we have no means of determining, nor can physical science be concerned with, any absolute reckoning of space and time. After this Einstein was led to the identification of mass with energy—another result of far-reaching importance,

which allows us to know the exact amount of the store of energy so tantalizingly hidden within the atom.

There was a feeling that this theory of relativity for uniform motion must be a particular case of something more general; but observational knowledge seemed to oppose a decisive negative to any extension. It was Einstein again who found the way to the generalization by bringing gravitation into his scheme.

Einstein's general theory of relativity is remarkable alike for the brilliance of conception and the mastery of the mathematical implement required to develop it. The new law of gravitation must be reckoned the first fundamental advance in the subject since the time of Newton. It involves an interaction between gravitation and light, which had indeed been suspected by Newton and almost taken for granted by Laplace, though it dropped out of scientific speculation when the corpuscular theory of light gave way to the undulatory theory. The three crucial astronomical tests of Einstein's theory have all been verified—the motion of perihelion of Mercury, the deflection of light, and the red-shift of the spectral lines. The last-named proved the most difficult to test, but there is now general agreement that it is present in the solar spectrum. More recently Einstein's theory of gravitation has appealed to astronomers not merely as something which they are asked to test, but as a direct aid to the advancement of astronomical research. Invoked to decide the truth of a suspicion of transcendently high density in the "white dwarf" stars, it has decided that in the companion of Sirius matter is compressed to the almost incredible density of a ton to the cubic inch.

The other direction in which modern physical theory has broken away altogether from the ideas of the nineteenth century is in the quantum theory. Probably no one would claim that he really understands the quantum theory. For such illumination as we do possess we are in great measure indebted to Professor Einstein. In 1905, almost at the same time as he published his first work on relativity, he put forward the famous law of the photo-electric effect, according to which the energy of a single quantum is employed in separating an electron from an atom and endowing it with kinetic energy. This was, perhaps, the first recognition that the development of the new quantum mechanics was not to be tied to classical mechanics by pictures of quasi-mechanical oscillators or other intermediate conceptions, but was to proceed independently on radically different principles. Noteworthy contributions followed on the theory of ionization of material, and on the problem of the specific heats of solids. In 1917 Einstein reached another fundamental result—namely, the general equation connecting absorption and emission coefficients of all kinds. This gives deep insight into the origin of Planck's law of radiation, besides providing new formulae with the widest practical applications.

THE AWARD OF GOLD MEDALS BY THE AMERICAN GEOGRAPHICAL SOCIETY

THE American Geographical Society has awarded the David Livingstone Centenary Medal for 1925 for "scientific achievement in the field of geography of the southern hemisphere" to Luis Riso Patrón, director of the Oficina de Límites of Chile in recognition of his contributions to Chilean cartography. Senor Patrón headed the first Chilean Commission to make a precise survey of the Cordillera of the Andes. He represented Chile in the Argentine-Chilean boundary arbitration (1902) and edited the maps of the Chilean boundary surveys. As director of the Oficina de Mensura de Tierras he was responsible for the great map of Chile on a scale of 1:500,000. His intimate knowledge of the geography of his country is revealed in the recently published "Diccionario Jeográfico de Chile" (1924).

Award of the David Livingstone Centenary Medal for 1926 is made to Erich von Drygalski, of the University of Munich, for his work in the South Polar regions. Dr. von Drygalski had already carried out notable glaciological investigations in the Arctic as leader of the Greenland Expedition of the Berlin Geographical Society (1891–1893) when he undertook the German Antarctic Expedition of 1900–1903. The latter expedition, which discovered a part of the Antarctic continent about the 90th meridian east, was characterized by an intensive study of all branches of natural science in the field of exploration. The important scientific results in 18 folio volumes appeared between 1905 and 1921.

The Charles P. Daly Medal for 1925 is awarded to Brigadier-General David L. Brainard in recognition of his notable achievements on the Lady Franklin Bay Expedition under Greely in 1881–1884. General (then Sergeant) Brainard took a leading part in the exploratory work of the expedition. In particular his name is associated with Lieutenant Lockwood's in the discoveries along the north coast of Greenland when the farthest north of the time, 83° 24′, was reached, a position only a few minutes of latitude from the northernmost point of Greenland.

The Charles P. Daly Medal for 1925 is awarded to Captain Robert A. Bartlett for his services to Arctic exploration. As commander of the *Roosevelt* (1905–1909) he took a leading part in Peary's expedition to the Pole. With a sledge party he himself reached a latitude of 87° 47′ N.—the highest latitude attained in the Arctic next to that of Peary himself. On the Canadian Arctic Expedition of 1913–1918 he commanded the *Karluk* and in the face of grave difficulties accomplished the rescue of the survivors from Wrangel Island, whither they had proceeded after the *Karluk* was crushed by ice. In 1917 under his able seamanship the Third Crocker Land Relief Expedition achieved success in the face of serious and exceptional ice conditions.

The Cullum Geographical Medal for 1925 is

awarded to Pedro C. Sanchez, director of the Central Mexican Bureau of Geography and Climatology in recognition of his contributions to Mexican cartography. Senor Sanchez has been in charge of the geodetic service of Mexico since 1912. He is responsible for the topographic survey of the Federal District on the scale of 1:100,000; the map of the state of Vera Cruz, 1:400,000 (1918), and the Atlas Geográfico de la República de México (1920). He has also conducted explorations in little-known parts of his country.

The Cullum Geographical Medal for 1925 is awarded to Harvey C. Hayes, research physicist of the United States Navy, for his invention of the Sonic Depth Finder. This instrument designed in the interests of navigation has put into the hands of science a practical means of mapping the ocean floor in detail and of furnishing data for more effective study of continent building and of the general problem of isostasy.

The Cullum Geographical Medal for 1925 is awarded to Lucien Gallois, of the University of Paris, for his work in the advancement of geography. His earlier studies established his reputation in the field of historical geography. His later work, embracing both physical and human aspects and finding expression in regional studies, furnishes an admirable exposition of the broad modern concept of geography. By his efforts as teacher, as collaborator and editor of the *Annales de Géographie,* and as president of the Association de Géographes Français, and especially by the spirit and method of his writings, his influence has carried far afield.

REVISION OF EDUCATIONAL METHODS IN THE YALE SCHOOL OF MEDICINE

A THOROUGHGOING revision of its educational methods with a view to placing less emphasis on routine class work and more on independent thought and research is planned by the Yale School of Medicine, according to an announcement made by Dean Milton C. Winternitz.

The faculty is considering the abolition of the year system of study and the resultant division of the student body into classes. This program will also involve the abolition of the system of examinations at the end of the different courses. The student will be allowed to select the sequence of his studies in the subjects which at present comprise the first two years of the medical curriculum, and then after qualifying for the clinical subjects, he will again be allowed liberty of choice. Their arrangement and his completion of them in any period of time will be largely a matter of his choice and ability. Admission to a course will depend on his fitness for the work as determined by the instructor in charge of it. This is the reverse of the present practice. A teacher now has no voice in determining what students shall enter his classes. He determines only whether they shall proceed into other classes. Thus, the student often thinks only of the examination which he is to take at the end of the year, and misses the application of the knowledge he is being offered.

Dean Winternitz made the following statement regarding the plan:

> These changes may seem radical but they are in accord with adopted systems of graduate education, and medical education is graduate education.
>
> There must, of course, be some check on the students' accomplishments; group examinations, as well as the graduating thesis, will serve this purpose. For the convenience of the faculty such examinations may be given at fixed times, but within reasonable limits the student may determine when he will present himself for such a test.
>
> Aside from other advantages, such a system will be equally valuable to the student who acquires knowledge rapidly and to his slower colleague. It is hoped that by the elimination of the class system, the pupil who acquires knowledge less rapidly will be less reluctant to spend more time in preparation, while the more brilliant scholar will be more willing to spend longer periods in investigation and specialization.

THE 1926 MEETING OF THE PACIFIC DIVISION OF THE AMERICAN ASSOCIATION

THE 1926 annual meeting of the Pacific Division of the American Association for the Advancement of Science will be held at Mills College, California, from June 16 to 19. Mills College is delightfully situated in the foothills near Oakland, California, and is easily accessible from all points of the San Francisco bay region. Established in 1852 it has played an important part in the intellectual life and development of the Pacific Coast and now stands unique as the only accredited college for women west of the Mississippi. With a campus of 150 acres, beautifully designed landscape and buildings, it will prove a most attractive and commodious meeting place for the annual meeting. As there is a large membership of the Pacific Division in this vicinity a very successful meeting is assured.

Preparations for the meeting are already in progress. A research conference, under the direction of President Aurelia Henry Reinhardt, will be arranged on the relation of the college to research. A symposium on the constitution of matter or a kindred subject will be arranged, with physicists of note participating, and one or more public addresses will be given by visiting European scientists.

It is likely that the greater portion of the 27

affiliated societies of the Pacific Division will arrange to hold their annual meetings at Mills College.

A meeting of the affiliation committee, comprising delegates from the various affiliated societies, will be held early in February to consider matters relating to their respective meetings.

The Executive Committee of the Pacific Division is constituted as follows:

Robert G. Aitken, president; associate director, Lick Observatory, Mount Hamilton, California.

Joel H. Hildebrand, vice-president and chairman of the executive committee; professor of chemistry and dean of men, University of California, Berkeley.

Walter S. Adams, director, Mount Wilson Observatory, Pasadena.

Bernard Benfield, consulting engineer, Kohl Building, San Francisco.

Leonard B. Loeb, assistant professor of physics, University of California, Berkeley.

E. G. Martin, professor of physiology, Stanford University.

Emmet Rixford, professor of surgery, Stanford University.

J. O. Snyder, professor of zoology, Stanford University.

O. F. Stafford, professor of chemistry, University of Oregon, Eugene.

SCIENTIFIC NOTES AND NEWS

DR. FREDERICK GARDNER COTTRELL, director of the Fixed Nitrogen Research Laboratory of the United States Department of Agriculture, has been awarded the gold medal for 1924 of the Mining and Metallurgical Society of America. The medal was presented at a luncheon held in his honor at the Cosmos Club, Washington, D. C., on December 7.

PROFESSOR A. N. TALBOT, head of the department of theoretical and applied mechanics in the University of Illinois, has been elected an honorary member of the American Society of Civil Engineers.

DR. C. E. K. MEES, director of research in the laboratories of the Eastman Kodak Co., has been made an honorary member of the French Photographic Society in recognition of his work on the fundamentals underlying the physics and chemistry of photography.

DRS. FEWKES, Swanton, Michelson and Mr. Hewitt, of the U. S. Bureau of Ethnology, have been notified of their election to honorary membership in the Hermann Barth Gesellschaft, of Vienna.

DR. RICHARD MOLDENKE, of New Jersey, was recently chosen to be the first recipient of the Joseph S. Seaman gold medal, awarded by the American Foundrymen's Association in recognition of his many contributions to the foundry industry.

MR. GEORGE EASTMAN, chairman of the board of directors of the Eastman Kodak Company, has been elected an honorary member of the Synthetic Organic Manufacturers Association in recognition of the work done by the company in its research laboratories in the manufacture of synthetic organic chemicals.

SIR WILLIAM BRAGG had conferred upon him the honorary degree of laws by St. Andrews University, on the occasion of the opening of the new laboratories of physics and chemistry at the University on December 4.

DR. HANS OSCAR JUEL, professor of botany at the University of Upsala, and Dr. Svante Marbeck, director of the Botanical Gardens at Lund, Sweden, have been elected foreign members of the Prussian Academy of Sciences.

PROFESSOR H. A. LORENTZ, of Leyden, on December 11 celebrated the fiftieth anniversary of his appointment as doctor of mathematics and philosophy. Among those who were present at Leyden University to honor the distinguished scholar were Professor A. S. Eddington, of Cambridge; Madame Curie, of Paris, and Professor Einstein, of Berlin.

DR. R. D. M. VERBEEK, the well-known East Indian geologist, has celebrated his eightieth birthday at The Hague. A "gift-book" was presented to him, containing forty-five scientific contributions from geologists in the Netherlands, the Netherlands East Indies, Japan, the Malay States, Indo-China, New Zealand, Australia, Papua, the Philippines, the United States, Germany and France.

THE university council of the University of Wisconsin has voted to recommend that the mining engineering building, which was largely designed by Dean Stephen M. Babcock and in which he carried on his work for seventeen years, be named Babcock Hall in his honor. Professor Babcock recently celebrated his eighty-second birthday.

S. W. PARR, professor of applied chemistry in the University of Illinois, has been elected to the board of directors of the American Chemical Society to succeed Professor William Hoskins, of Chicago.

DR. HARRY C. OBERHOLSER, ornithologist in the Biological Survey of the United States Department of Agriculture, has been elected president of the Biological Society of Washington.

DR. A. J. CARLSON, professor of physiology at the University of Chicago, was elected president of the Institute of Medicine of Chicago at a meeting of the board of governors on December 9. Dr. Robert B. Preble was elected vice-president; Dr. George H. Coleman, secretary; Dr. John Favill, treasurer, and Dr. Ludvig Hektoen, chairman of the board.

DR. ALBERT W. BUCK, of the Johns Hopkins Hospital, has been named superintendent of the New Haven Hospital, to succeed Dr. Willard C. Rappleye, who recently resigned to become chairman of the International Commission on Medical Education.

EARL H. MORRIS, who has been in charge of the excavations and the restoration work of the Carnegie Institution's Chichen Itza project, is to return to the American Museum of Natural History as associate curator of American archeology.

DR. MARGARET MEAD, now studying among the Samoans as an anthropological fellow of the National Research Council, has been appointed assistant curator of ethnology of the American Museum of Natural History. She will take up her duties in September.

ROSCOE NUNN, of Nashville, Tenn., has been appointed meteorologist in charge of the Baltimore Weather Bureau Station to take the place of James H. Spencer.

WALTER F. RITTMAN, of the Carnegie Institute of Technology, has been appointed consulting chemical engineer to the Fixed Nitrogen Research Laboratory of the Department of Commerce.

PROFESSOR V. V. USPENSKY, a member of the Russian Academy of Science, has been appointed lecturer in mathematics at the University of Michigan for the semester beginning next February.

SIR RONALD ROSS, director of the new Ross Institute of Tropical Diseases, left for Ceylon on December 11. His journey is being undertaken at the invitation of the Ceylon Association and he will investigate conditions in the island from the point of view of malaria control.

DR. KEIJI ITO, consulting engineer of the Toho Electric Power Company and professor of the Tokyo Institute of Technology, is visiting the United States, where he is making a study of the application of motors to industrial equipment and household appliances.

DR. VLADIMIR ULÉHLA, professor of plant physiology in the University of Brunn, Czechoslovakia, who has been working with Dr. D. T. MacDougal, of the Carnegie Institution of Washington, sailed for Europe on December 19. Dr. Uléhla has visited many laboratories in the United States for the purpose of obtaining information to be used in completing the buildings and equipment of the laboratories of the University of Brunn.

DEAN WILLIAM FREDERICK BADE, of the Pacific School of Religion, will be the delegate of the University of California to the Archeological Congress, which convenes in Jerusalem next May. Dr. Bade is also heading an archeological expedition to Palestine, the British Department of Antiquities having signified its intention to grant him a permit to excavate Tel-en-Nasbeh (by many regarded as the biblical Mizpah), near Jerusalem, during the coming spring.

F. D. KERN, head of the department of botany and dean of the graduate school at Pennsylvania State College, has been granted a year's leave of absence ending July 1, 1926, and from September to June is serving as acting dean of the college of agriculture of the University of Porto Rico.

PROFESSOR CHARLES SCHUCHERT, of Yale University, will give a course in stratigraphic geology at the University of Texas during the winter term of the present year. The course will include principles of stratigraphy; the stratigraphy of North America with special reference to the Paleozoic and Mesozoic; and index fossils which characterize the major divisions of the geologic record.

DR. GEORGE L. STREETER, chief of the department of embryology of the Carnegie Institution, Washington, D. C., gave an illustrated lecture before the Baltimore City Medical Society on December 4 on "The Miller Specimen, the Youngest Known Human Embryo." Dr. Dean Lewis, of the Johns Hopkins University Medical School, spoke on "Surgical Diseases of the Large Bowel."

DR. HENRY SEWALL, emeritus professor of medicine, University of Colorado School of Medicine, will give a series of six lectures for the San Diego Medical Lectureship Fund, San Diego, beginning January 4, 1926, on "Physiology," which will pertain chiefly to the metabolism of respiration and the endocrines.

THE University of Liverpool has established a post-graduate scholarship in oceanography in memory of the late Sir William Herdman. A sum of £1,000 has been contributed for this purpose.

PROFESSOR EDWARD SYLVESTER MORSE, director of the Peabody Academy in Salem, Mass., and formerly professor of comparative anatomy and zoology at Bowdoin College and at the University of Tokyo, died on December 21 in the eighty-eighth year of his age.

DR. JOHN TAYLOR BOTTOMLEY, associate in surgery in the graduate courses in medicine at the Harvard Medical School, died on December 17 in the fifty-seventh year of his age.

DR. JAMES T. PRIESTLEY, of Des Moines, Iowa, for many years a prominent physician and well-known scientific man in the West, died on December 11 at the age of seventy-four years. He was a grandson of Joseph Priestley, the discoverer of oxygen.

DR. EDMUND KNECHT, associate professor of ap-

plied chemistry in the University of Manchester and in the College of Technology, died on December 8 at the age of sixty-four years.

DR. JAMES MURIE, the English naturalist, has died at the age of ninety-five years.

W. P. HIERN, F.R.S., the well-known systematic botanist of England, recently died, aged eighty-five years.

DR. W. R. DYKES, secretary of the Royal Horticultural Society, London, and an authority on the genus Iris, died on December 1, aged forty-eight years.

DR. CARL SCHOY, who was recently called to the University at Frankfort-am-Main to take charge of the work in the history of oriental mathematics, died on December 6 at the age of forty-eight years. A correspondent writes that Dr. Schoy was well known as a writer on the history of Arabic mathematics. Although he took up the study of the subject rather late in life, he made great progress in his work, and during the last few years he has written a number of important memoirs upon the subject of Arabic mathematics and astronomy.

SECTION officers for the Seventh Annual Meeting of the Southwestern Division of the American Association for the Advancement of Science, which meets from February 15 to 18, are as follows: Biology, Charles T. Vorhies, *chairman,* University of Arizona; Dr. W. P. Taylor, *secretary,* University of Arizona; education, Dr. Frank C. Lockwood, *chairman,* University of Arizona; Dr. J. O. Creager, *secretary,* University of Arizona; medical science, Dr. Gerald B. Webb, *chairman,* 402 Burns Building, Colorado Springs; Dr. I. E. Wallin, *secretary,* University of Colorado Medical School, Denver; Physical Science, Dr. O. C. Lester, *chairman,* University of Colorado; Professor F. M. Life, *secretary,* University of Arizona; social science, Professor E. B. Renaud, *chairman,* University of Denver; Henry B. Roberts, *secretary,* University of Denver. Members wishing to present papers in any of the above sections should send titles to the proper section chairman. Papers on special subjects not covered by any of the above sections should be submitted to the executive committee, A. L. Flagg, *chairman,* 306 Goodrich Building, Phoenix, Arizona.

THE American Association of University Professors held its twelfth annual meeting at the University of Chicago on December 28 and 29. The program included the election of officers; the presentation of committee reports, a luncheon with the Modern Language Association, and the annual dinner at which the principal speakers were President Max Mason, of the University of Chicago, and Professor A. O. Leuschner, of the University of California, president of the association.

THE next meeting of the American Chemical Society will be held in Tulsa, Oklahoma, from April 5 to 9.

THE scientific society known as the Priestley Club, founded in 1875 to promote the discussion of scientific topics and facilitate the social intercourse of scientific men, celebrated the attainment of its jubilee by a dinner at the University of Leeds, England, on December 15. The speakers included Sir J. C. Irvine, principal of St. Andrews University, the vice-chancellor of Leeds University and Professor Arthur Smithells.

THE National Research Council, operating on a grant of $50,000 provided by the General Education Board of New York, has undertaken the study of a new forestry policy for the United States and its workers are about to begin an examination of all the sciences, from the directly related subjects of botany and zoology to the ones more remotely concerned, like geology and chemistry, with a view to correlating all the information obtainable in the development of new ideas. The survey was first proposed by Chief Forester W. B. Greeley, of the U. S. Forest Service, and will be carried through by Dean H. S. Graves, of the Yale University school of forestry; Professor I. W. Bailey, of Harvard University, and Dr. H. A. Spoehr, of the Carnegie Institution of Washington.

THE General Education Board has made an appropriation of $35,000 to the American Chemical Society to insure the publication of the second decennial index of *Chemical Abstracts.* Therefore the directors of the society have been able to authorize the work and the editor will take immediate steps to begin the preparation of the material.

IT is reported that the sum of over $250,000 has already been collected in Germany for Dr. Eckener's fund to build a Zeppelin for scientific exploration.

THE collections made by Dr. Aleš Hrdlička in South Africa have reached the U. S. National Museum. They comprise fragmentary fossils of apes from the Taungs (Buxton) quarry; paleolithic implements from Bechuanaland and the Zambesi, and a series of decorated baskets from Northern and Southern Rhodesia.

MEMBERS of the Sterling expedition to New Guinea, under the auspices of the Smithsonian Institution, completed the second part of their journey recently, arriving in Manila on December 24. The expedition next will go to Batavia, where outfitting will be completed.

THE Smithsonian Institution has arranged to fur-

nish through the United States Weather Bureau, the telegraph companies, the Associated Press and Science Service, daily or 10-day mean values of the solar constant of radiation for use in weather forecasting, beginning on January 1. For the purpose of studying the solar constant of radiation, the Smithsonian Institution has established observatories on the top of the Andes Mountains in Chile and on Table Mountain, California. It is from these stations that the institution proposes to broadcast through the agencies named, if they wish the information, the values of radiation.

IN consideration of the excessive use of laurel, ground pine and holly for Christmas decorations, the Brooklyn Botanic Garden held an exhibit from December 8 to 23, the purpose of which was to show cultivated plant materials which should prove satisfactory as substitutes for the wild plants above mentioned.

ACCORDING to the *American Medical Journal*, a research section has been established by the U. S. Veterans' Bureau, and Dr. Philip B. Matz has reported to the central office for duty as chief. The purpose of the section is to study available medical data, the results accomplished, the developments of new policies, and the investigation of standards in medical centers for improvement of clinical work and the furtherance of research. The chief will be responsible for the study of the clinical material in the hospitals and outpatient departments of the bureau, with particular reference to the results of treatment. He will survey the records kept in the central office and in the field to determine their adequacy for the purpose of investigation. Certain laboratories of the bureau will be designated as research laboratories, which in addition to caring for the routine of the institutions concerned will engage in broader work to be assigned from time to time. These laboratories will also be distributing centers for culture mediums, standardized solutions, Wassermann reagents, typhoid and other cultures and various agglutinating serums.

THE International Institute of Intellectual Cooperation, of the League of Nations, has according to the London *Times* settled into the offices which have been provided for it in Paris by the French government. It occupies a large suite of rooms in the southern end of the Palais Royal, overlooking the gardens, a suite which includes a fine range of galleries. The Director of the Institute is M. Julien Luchaire, who has at present a staff of about forty persons working under him on the task of establishing a clearing house of information from all countries, which will be of use in guiding students in their researches.

UNIVERSITY AND EDUCATIONAL NOTES

PRINCETON UNIVERSITY has received a gift of $1,000,000 from the General Education Board for increases in equipment and facilities for advanced teaching and research in the physical and biological sciences. This endowment is conditional on Princeton's raising an additional $2,000,000 for the same purpose.

THE board of trustees of Johns Hopkins University has approved the plan to abolish the undergraduate school at the university. To become effective the plan must now be approved by the State Legislature.

RAWSON LABORATORY, a $600,000 six-story building, was dedicated on December 17 as a part of the Rush Medical College of the University of Chicago.

IT is reported that the Rockefeller Foundation, of New York, has offered to establish reciprocal research scholarships, somewhat similar to the Rhodes scholarships, between American and Australian universities. Professor Copeland, of Melbourne University, has been invited to the United States to arrange the details of the plan, and the university council has granted a leave to him.

DR. PARKE REXFORD KOLBE, formerly president of the Municipal University of Akron, will be installed as the new president of the Brooklyn Polytechnic Institute on January 13.

DR. ERWIN RUDOLPH SCHMIDT, of the staff of the Augustana Hospital, has been appointed professor of surgery at the University of Wisconsin and surgeon of the Wisconsin General Hospital, to take the place of Dr. Carl A. Hedblom, who recently resigned to accept a similar position at the University of Illinois.

DR. FREDERICK HOWARD FALLS, professor of obstetrics and gynecology at the University of Iowa, has accepted an appointment to head similar work at the University of Illinois in the medical school in Chicago.

PROFESSOR H. WILDON CARR, of London, is serving as visiting professor of philosophy at the University of Southern California during the current academic year.

DR. HENRY STEPHEN, senior lecturer in chemistry at the University of Manchester, has been appointed to the chair of chemistry in the University of the Witwatersrand, Johannesburg.

PROFESSOR H. A. BROUWER, of the Technical Institute at Delft, Holland, has been appointed professor

of geology at the University of Utrecht. Dr. Brouwer will not leave the chair of geology at Delft, but will go to Utrecht to give his courses.

PROFESSOR HANS RADEMACHER, of the University of Hamburg, has been appointed professor of mathematics at the University of Breslau.

DISCUSSION AND CORRESPONDENCE

PROJECTION OF ULTRA-VIOLET LINES

RECENTLY, when attempting without quartz lenses or prisms to demonstrate the existence of ultra-violet lines in the spectrum of mercury, I projected the image of a slit in front of a "Laboratory Standard" mercury vapor lamp onto a "day-light screen" (Trans-Lux), using only a flint prism and a single crown lens. I expected to use a fluorescent screen to pick up the ultra-violet lines but found that the trans-lux screen showed these lines up, though not brightly. The lines were easily visible at a distance of five feet.

I could only convince myself that these were ultra-violet lines by these arguments: (1) the lines were not at all the correct color for the violet end of the spectrum; (2) they were not due to stray light; (3) when falling on anthracene they produced fluorescence, even when the slit was covered with an ultra-violet wave-filter.

Perhaps a more powerful source of light, with proper lenses and prism, would bring these lines out strongly enough for a large lecture room, especially when the wave-filter cuts off the visible spectrum.

PAUL F. GAEHR

WELLS COLLEGE

INFLUENCE OF AIR AND SUNSHINE ON THE GROWTH OF TREES

A CASE came under my observation this past summer that will furnish an example of some value to teachers of botany and crop production of the advantage of ample air and sunlight for growing plants.

Mr. A. L. Rogers, of Waterville, Washington, in order to study past variations in climate in that locality, made a section of a forest tree for the purpose of studying the thickness of the annual growth rings and correlating variations in this thickness with known variations in rainfall for the past thirty-three years—the records of rainfall being available for that period. I recently had the opportunity of examining the section. Assuming that a ring of growth has been made each year, the tree was a seedling in the year 1820. Up to, and including the year 1898, the average thickness of the annual rings was approximately one sixteenth of an inch. Beginning with the year 1899, and extending to 1924, when the tree was cut, the rings had an average thickness of approximately three sixteenths of an inch. I suggested to Mr. Rogers that the region must have been logged off in the winter of 1898–9; that previous to that time the tree had been closely surrounded by other trees and thus was unable to secure the necessary air and sunshine for maximum growth; that after the logging off, the rate of growth of the tree had been about tripled.

Investigation revealed that this suggestion was in accordance with the facts. Several stumps, much decayed, were found in the immediate vicinity of the tree, and the date of the logging off operations proved to be the date suggested by the change in rate of growth of the tree.

Additional moisture available to the tree after the logging operations may also have been a factor in the increased rate of growth.

W. J. SPILLMAN

U. S. DEPARTMENT OF AGRICULTURE

AN UNUSUAL STRAIN OF SERRATIA MARCESCENS BIZIO

A STRAIN of *Serratia marcescens* which, so far as we have any knowledge, has been kept in the laboratory of the department of botany of Wellesley College for at least four years, has developed characteristics unusual for this species. It seems worth while to make a brief note of these variations.

The following culture reactions were obtained with this organism: agar streak varying from white to pink and red, taking on a very bright color and metallic luster with age, *the pigment sinking into the agar,* in some instances for several millimeters; *pigment formed at 35° C.–37° C., soluble in water* and alcohol, slightly soluble in chloroform; gelatin liquefied rapidly, the medium becoming red; nutrient broth turbid after two days, then becoming *red throughout* and showing a thin pellicle; no gas in *dextrose,* sucrose or lactose broths after two weeks, dextrose and sucrose acid; the reaction in lactose broth was rather peculiar and necessitated more extended experimentation which can not be reported at this time; indol not produced; nitrates reduced to nitrites; potato agar showing a very luxuriant, rose-colored growth; growth on starch agar as on nutrient agar and the color bright red; 30 per cent. peptone agar, producing a very light pink growth; litmus-milk acid and coagulated with little or no peptonization. The form is Gram negative, and motile with peritrichous flagella. The italics indicate the deviations from the description given in Bergey's Manual.[1]

[1] Bergey's "Manual of Determinative Bacteriology," Williams and Wilkins, Baltimore, 1923.

The variability of this species has been noted repeatedly by observers, and there has been much discussion as to its ability to form gas in carbohydrates. Miss Hefferan,[2] who has done the most comprehensive work on this group, found in eight strains of *S. marcescens* (*B. prodigiosus*) gas formation in dextrose in seven, in sucrose in four and in lactose in one. Her *B. prodigiosus* VIII formed no gas in any of the three sugars used. In this respect our form agrees with VIII and differs from all the rest of her series and from the type described by Bergey.

Miss Hefferan also found among the eight strains variations in viscosity, in the amount of color in broth, and in the presence of a pellicle on broth cultures. *B. prodigiosus* I, II, III, IV, VI and VII produced slight color in liquids and a red surface ring; V produced a heavy orange-red membrane and VIII only a pink, or violet, surface ring. Our strain colored bouillon a brilliant rose red throughout, with a thin pellicle, thus differing from any strain previously described. This excessive pigment formation is the most striking characteristic of this form. In a few days agar streaks become a most brilliant red, varying from scarlet to crimson, while the upper layer of agar becomes deeply stained with pigment. In the solubility of this pigment in water this form differs from all descriptions of *Serratia* species which have come under our notice. Pigment formation takes place at high temperatures—30° C. to 37° C.—which is also a variation from *S. marcescens,* but is characteristic for related species.

The suggestion that the excessive pigment formation might be due to contamination with some other form was tested by repeated platings and a study of many slides. The white colonies, which were considered as possible contaminations, invariably, upon being streaked on agar, produced red growths, and the slides showed apparently pure cultures with Gram's stain and carbol fuchsin. Single-cell isolation would have made this point certain, but time has not been available for this work.

RACHEL SCHREINER
LAETITIA M. SNOW

WELLESLEY COLLEGE,
WELLESLEY, MASS.

THE CLEARNESS OF THE OHIO RIVER

IN the body of the interesting address by Dr. Alexander Findlay on "The twilight zone of matter"[1] is a statement which seems too indefinite to be taken broadly, in view of the nature and importance of the matter under discussion. The comparative clearness of sundry river waters as affected by the presence or absence of colloids is under discussion, and the statement is made:

"The water of the Ohio River, on the other hand, is at all times clear, owing to the absence of protective colloids and the presence of lime and other salts which act as precipitating agents."

The Mississippi and Nile are the rivers included in the reference to "on the other hand" in the above quotation. Taking the statement as made we would first of all point out that the analysis of no great river such as any of those mentioned can safely be taken at any point as truly representing the colloidal or any other condition of the whole stream; certainly not in the case of the Ohio. As the writer can testify from personal observations of his own, and as might be inferred by an inspection of the geological nature of the regions drained by the Ohio, such a statement as the one made above becomes meaningless unless restricted to a particular stage of the river. The two separate rivers forming the Ohio at Pittsburgh, *viz.,* the Allegheny and the Monongahela, are not in themselves at all times clear nor does the resulting river, the Ohio, become so or remain so during its entire course. As a matter of fact, one of the muddiest rivers I have ever seen is this river at Cincinnati, even after it has received the limestone waters of the several streams, Miami, etc., from its course along the southern boundary of the state of Ohio, and after it has been the recipient of all sorts of factory and industrial refuse matter, mine waters, sewage, etc. In short, the Ohio, like its sister, the Mississippi, is not a hydrographic unit, nor are sweeping assertions as to its colloidal behavior to be accepted as at all times, or at all stages correct; there are other factors involved in the discussion besides the relation of lime to colloids. Very probably the quotation as used did not originate with Dr. Findlay, but is to be taken rather as typical of certain general assertions, lacking carefully coordinated data. The statements have been going the rounds for many years that limestone drainage acts as a clarifying agent in natural waters; it may be true that it does up to a certain point. But there are streams in southern Ohio so saturated with lime salts that freshwater mussels flourish in them; the pebbles become in time coated by lime, as do also submerged tree trunks, but at the same time the waters are seldom clear; clays, "muds" in general, all the usual inwash of a cultivated and populated region. Probably most scientific persons who have given any time and ob-

[2] Hefferan, Mary, "A comparative and experimental study of bacilli producing red pigment." *Centrbl. f. Bakt.* Abt. II., Bd. XI, p. 311–540, 1904.

[1] SCIENCE, LXII, 1600, p. 195.

servation to the behavior of river waters and natural drainage will be willing to admit the great importance of colloidal action in natural river waters, but this truth will not be abetted in any way by the circulation of statements which lack coordination with the other equally important factors in the case.

So far as lime salts are concerned it would seem to be true of fresh waters as it is of sea waters that organic life and organic "matter" tends to remove them, and that in so doing will pull down an appreciable quantity of other suspended matter. The clarity or non-clarity of the resulting stream will then depend, will it not, upon another adjustment of factors such as the relative amounts of "clay matter" suspended in it, the intake of other streams along its course, and the degree of removal of the original lime and organic matter. It has always seemed to the present observer that the condition of the lower portions of such streams as the greater rivers, the Nile, Mississippi, Ohio, etc., is a sort of survival from a series of natural "experiments" rather than due to the action of one set of factors; and that assertions to the effect that a certain river always does this or that are true only when, as is not always the case, a definite series of like reactions are set up. The apparent preponderance of the "lime salts" over organic matter in the final stages of the Mississippi, and indeed the relative abundance of any of the usual "salts" commonly recorded in water analyses are still in too chaotic a state of coordination with modern ideas of ionization, etc., to be taken too weightily. That colloidal action plays an important part in the reactions constantly in process in river waters may presumably be taken as correct; that such actions play the all-important or even the most important part in such reactions is another matter and is by no means to be given the preeminence ascribed to it in the quotation as given.

FREDERICK EHRENFELD
LABORATORY OF GEOLOGY,
UNIVERSITY OF PENNSYLVANIA

SCIENTIFIC BOOKS

The Osteology of the Reptiles. By SAMUEL WENDELL WILLISTON. Arranged and edited by William King Gregory. Cambridge, 1925. The Harvard University Press. Price $4.00.

A THING that has been lacking hitherto in the literature of vertebrate palaeontology is a comprehensive and adequate treatise on the osteology of reptiles. There have been many excellent discussions of the osteological characters of special groups and a certain amount of high-grade text-book treatment of the skeleton of the Reptilia. None of these could fill the need of a comprehensive reference book on reptilian osteology.

This need Williston's "The Osteology of the Reptiles" has filled in an admirable manner. The book is divided into two sections; the first, comprising two thirds of the volume, deals with the reptilian skeleton from a strictly morphologic viewpoint; the second, comprising the remaining third, consists of a brief classification of the Reptilia, with definitions of the major groups and many of them minor ones.

The section on the primitive skeleton of reptiles, in the introduction, is a discussion of particular value. Professor Williston's specialty, in his later years at least, was the morphology of the Permian amphibians and reptiles, and his account of the primitive reptilian skeleton forms a very adequate groundwork for the discussion of the skeleton in the later and more specialized groups. The tabular key of the bones of the primitive skeleton sums up for the student the names of the bones of the reptile skeleton and their location in a very clear and compact way.

Following the introduction is a chapter on the skull of reptiles, occupying nearly a third of the book. Horns, processes, fenestrae, etc., are given a general discussion and their more striking modifications in the various groups are noted. Then the bones of the skull are considered one by one, their primitive positions and contacts noted and their special characters and modifications in the later and more highly specialized reptilian groups discussed. A table of synonyms of names of skull bones adds to the usefulness of this section.

Following the discussion of the separate skull elements is a series of sections dealing with the skull in the various orders of reptiles, noting general form, elements present, degree and kind of fenestration, dentition and adaptive modifications.

After the chapter on the reptilian skull is one on the vertebral column, in which the vertebra are discussed and their elements, developments and modifications, both as individual vertebra and as regions of the vertebral column.

Similar chapters follow on ribs and sternum, pectoral and pelvic girdles and limbs. In each of these the primitive characters of the Permian reptiles are discussed adequately and the modification from the primitive conditions considered as such.

This part of the volume is complete in itself and might be used independently of Part II, which deals with the classification and systematic treatment of the reptilian orders.

Part II begins with a brief chapter on the principle or problem of classification, which points out clearly the difficulties in the way of arriving at a

comprehensive and accurate genealogical classification of reptiles. The principles upon which the present classification is founded are discussed and an account of the early evolutionary history of the Reptilia is included. A diagram showing the classification of the reptiles and amphibians follows this chapter.

The classification of the reptiles is outlined in synoptic form in Chapter VII. Five subclasses, Anapsida, Synapsida, Synaptosauria, Parapsida and Diapsida are listed and a brief definition of the characters of each is given. Nineteen orders and their various suborders are listed and defined briefly.

Five chapters following the synoptic classification deal with the five reptilian subclasses. In each of these the various orders and suborders, intermediate groups and families are listed and defined. One or two apparently inadvertent omissions in this treatment, such as the coelosaurid, megalosaurid and deinodont theropods, are unfortunate.

While there may not be unanimous agreement regarding the status of some groups in the classification, such as the Parapsida possibly, there can be no doubt that this is the most adequate, well-defined classification of the Reptilia that has been proposed, possibly the most natural one. It is largely in agreement with that published by Broom in 1924.

The book is illustrated by nearly two hundred text figures, partly drawings by the author and partly derived from other sources, for which credit is always given. The figures are well chosen and illustrate very well the characters discussed. Complete cross-references in the text bind text and figures together in a way that increases the value of both.

The editorial work upon the volume consists of more than the usual editorial preparation and oversight of the text and illustrations. Numerous comments in brackets by the editor call attention to different viewpoints by various authors, especially to work done since Williston's death in 1918. This applies particularly to notice of recent work by Broom, Watson and other specialists on the earlier reptiles. These comments serve partially to bridge over the gap between the preparation of the manuscript by Williston in 1918 and earlier and its publication in 1925. An alphabetical finding index of genera would have been a useful addition.

The small and convenient size of the book (three hundred pages, octavo), its attractive appearance and its reasonable price ought to insure widespread use of the volume aside from the value of its contents. It is really surprising to find the wealth of useful, accurate, thoroughly digested information this book contains in so small a space. *"The Osteology of the Reptiles"* is the final work of a distinguished morphologist and paleontologist. It is based upon many years of thorough, patient work upon the earlier reptiles by a brilliant mind. It includes also the mature results of the author's studies of the later reptiles. The information is clearly expressed and compact and is readily available to inexperienced students and more mature research workers alike.

The book fills a place long empty in scientific literature and is a credit to every one concerned with its appearance, first its author, the late Professor Samuel Wendell Williston, and also to its sponsors, Professor T. H. Barbour and the Harvard University Press, and its editor, Professor William King Gregory and his associates.

CHARLES C. MOOK

AMERICAN MUSEUM
OF NATURAL HISTORY

SPECIAL ARTICLES

THE PRESENCE OF SULPHATE REDUCING BACTERIA IN OIL FIELD WATERS

Statement of the problem: The reduction of sulphates in sea water and the waters of certain springs through the agency of living microscopic organisms has been well established by the researches of Sir John Murray and many other observers whose work will be cited in a more detailed paper to be published later. The following equations are types of those which have been postulated by these observers to explain the results of these reactions of metabolism.

1a. $CaSO_4 + CH_4 \rightarrow CaS + CO_2 + 2H_2O$.
1b. $CaS + CO_2 + H_2O \rightarrow CaCO_3 + H_2S$.
2. $Na_2SO_4 + CH_4 \rightarrow Na_2S + CO_2 + 2H_2O$.
2a. $Na_2S + CO_2 + H_2O \rightarrow Na_2CO_2 + H_2S$.
3. $CaSO_4 + 2C \rightarrow CaS + 2CO_2$.
4. $MgSO_4 + 2C \rightarrow MgS + 2CO_2$.
5. $Na_2SO_4 + 2C \rightarrow Na_2S + 2CO_2$.

Within recent years geological studies principally in the United States have disclosed evidence of the reduction of sulphates with the concomitant development of hydrogen sulphide and of carbonates in the deeply buried waters of oil fields.[1] Somewhat analogous conditions have been postulated by Siebenthal[2] in the zinc districts of Missouri, Oklahoma and Kansas.

Although most of the equations above listed were originally written to express reactions recognized as due to living organisms, geologists concerned with the reduction of sulphates in connection with oil have

[1] G. Sherburne Rogers, "The Sunset-Midway Oil Field, California," Professional Paper 117, U. S. Geological Survey, 1919.

[2] C. E. Siebenthal, "Origin of the Lead and Zinc deposits of the Joplin region," Bull. 606, U. S. Geological Survey, 1915.

assumed, not unnaturally, that sulphate reducing organisms could not live under the conditions existing in the oil sands. They have postulated therefore that reaction of the types cited could proceed without the aid of living organisms.

In view of the great geologic importance of the natural reduction of sulphates, it has seemed desirable to critically examine the validity of the two postulates:

I. That sulphates may be reduced under conditions existing in nature by reactions like those cited above, *without the aid of living organisms.*

II. That living sulphate-reducing organisms do not and can not exist in the waters found in oil sands.

The preliminary results of this critique will now be summarized, the full details being reserved for a later paper.

I

SULPHATE REDUCTION BY DEAD ORGANIC MATERIAL

While it is well known that some of the reactions cited above can take place in the absence of organisms at *high temperatures,* no experimental evidence has thus far been recorded, so far as known to the writers, to show that they can proceed at the moderate temperatures that characterize oil-field waters. On the other hand, thermo-chemical considerations seem to be opposed to their progress at ordinary temperatures.

The validity of equation No. 1, for the reduction of $CaSO_4$ by methane at ordinary temperatures, is brought into serious question by the work of Marino and Danesi,[3] who succeeded in obtaining this reduction only at high temperatures close to the explosion point for methane. At these temperatures some dissociation to CaS and CaS_2O_3 took place.

The reduction of $CaSO_4$ by carbon, as expressed by equation 3, has been investigated by Hofman and Mostowitsch.[4] Chemically pure calcium sulphate and sugar charcoal were used and the reduction carried on in a neutral atmosphere of nitrogen at atmospheric pressures. It was found that reduction began at 700° C. and was practically complete at 1000° C.

As pointed out by Palmer[5] the reaction of equation 5 is the one involved in the LeBlanc process of soda manufacture, in which the mixture of sodium sulphate and charcoal is heated for a considerable period at 1000° C. The reaction is strongly endothermic.

With regard to the reduction of ferrous sulphate by organic matter, Allen, Crenshaw and Johnson[6] conclude: "Some experiments have been tried in this laboratory in the hope of 'reducing' ferrous sulphate with organic matter, but the results have not been promising. The action of starch and glucose in aqueous solutions at 300° C. was either slight or nil. On the other hand, the possibilities of hydrogen sulphide are suggestive."

Some simple experiments were conducted by Bastin and Merritt to test further the possibilities of reduction of sulphates at ordinary temperatures by coal, crude petroleum and oil shales. Calcium sulphate and cupric sulphates singly or together were the sulphates chosen. The use of cupric sulphate, it should be noted, insured aseptic conditions and eliminated any possibility of bacterial action. Furthermore, any development of hydrogen sulphide or other soluble sulphide would immediately have manifested itself by the precipitation of cupric sulphide. Hydrogen sulphide was further tested for with lead acetate, and carbonates were tested for by acidulation with hydrochloric acid. Most of the tests were continued over periods of from 60 to 170 days. *In no instance was there any evidence of reduction of sulphates or development of carbonates.*

From the data given above, it must be concluded that no valid evidence has as yet been obtained of the reduction of sulphates by dead organic material at ordinary temperatures. It is of course entirely possible that such evidence may be obtained in the future.

II

PRESENCE OF SULPHATE-REDUCING BACTERIA IN OIL-FIELD WATERS

In 1919, G. Sherburne Rogers published the results of his very detailed chemical and geologic study of ground water conditions in the Sunset-Midway Oil Field, California. In this report he showed that whereas the surface and near-surface waters of the region are rich in sulphates, the waters associated with the oil are free or nearly free from sulphate but carry carbonate instead. He attributed the paucity or absence of sulphates to the reducing action of the petroleum, the sulphates originally present being reduced with the development of hydrogen sulphide or other sulphides. He concluded that the reduction took place at temperatures little above ordinary and through the agency of the dead organic materials of the oil.

The field and laboratory data presented by Rogers

[3] L. Marino and D. Danesi, *Gazz. chim. Ital.,* Vol. 43, pp. 423–434.

[4] H. O. Hofman and W. Mostowitsch, "The reduction of calcium sulphate by carbon monoxide and carbon, and the oxidation of calcium sulphide," *Trans. Amer. Inst. Min. Eng.,* Vol. XLI, 1910, pp. 763–785.

[5] Chase Palmer, "California oil field waters," *Econ. Geol.,* XIX, 1924, p. 628.

[6] Allen, Crenshaw and Johnson, "The mineral sulphides of iron," *Amer. Journ. Sci.,* XXXIII, 1912, p. 171.

are very convincing, but are in conflict with the experimental results that have been summarized in Section I above. It seemed desirable, therefore, to test the waters from certain oil fields to determine whether the tacit assumption of the absence in them of sulphate-reducing bacteria was correct. Unfortunately these tests could not be carried out in the Sunset-Midway Field, but the Illinois State Geological Survey offered facilities for collecting water samples from oil-bearing horizons in southeastern and southwestern Illinois. Preliminary tests on oil-field waters from Clark County were successful in showing some sulphate-reducing bacteria and were followed by the development of favorable culture mediae and by further tests of a considerable number of samples. These further tests showed such bacteria to be abundant in a large majority of the samples collected.

Samples were collected from 19 wells in southeastern Illinois and 6 in southwestern Illinois. The wells selected were most of them yielding waters low in sulphates and containing hydrogen sulphide. All the waters either have been or will be submitted to chemical analysis and the results will be reported in the final paper. All thus far analyzed are dominantly sodium chloride brines with minor amounts of K, Ca, Mg, HCO_3 and SO_4 radicles. They resemble normal sea-water in composition but are lower in sulphate content. They resemble also the salt waters associated with the oil in the Sunset-Midway Field, California.

The oil-producing horizons from which the samples were obtained ranged from Pennsylvanian to Ordovician in age and lay at depths of from 450 to 1,700 feet.

Mr. Gail Moulton and his assistant, Mr. C. R. Clark, collected many of the samples and supplied all the data concerning their field occurrence. The collections were made in bottles previously sterilized in the bacteriological laboratory, and all the precautions usual in taking samples for bacterial analysis were observed. The samples were the mixtures of salt water and oil that constitute the regular yield of the wells, the oil being much subordinate to the water. The samples were taken direct from the pumping jacks of wells that had been pumping continuously for days or weeks and the sample clearly came from the producing oil horizon with little possibility of contamination from sources higher up. Any organisms present in these salt waters were tolerant of (if not dependent on) the presence of petroleum.

The samples were submitted to bacteriological study by Frank E. Greer, in the bacteriological laboratory of the University of Chicago, within a few days of their collection.

Two culture mediae in eight phases were used as follows:

Medium 1.1—K_2HPO_4 ..... 0.5 g.
Asparagin 1.0
Magnesium sulphate 2.5
Sodium lactate 5.0
Mohr's salt (Ferrous ammonium sulphate) ..... Trace.
Distilled water ..... 1 liter

" 1.2—Same as 1.1 with 30 g. NaCl.
" 1.3—Same as 1.1 with 30 g. agar.
" 1.4—Same as 1.2 with 30 g. agar.

Medium 2.1—K_2HPO_4 ..... 0.5 g.
Ammonium sulphate 2.0
Sodium sulphate 2.0
Iron lactate 5.0
Distilled water ..... 1 liter.

" 2.2—Same as 2.1 with 30 g. NaCl.
" 2.3—Same as 2.1 with 30 g. agar.
" 2.4—Same as 2.2 with 30 g. agar.

These mediae were tubed in large test-tubes and sterilized in autoclave at 15 lbs. pressure for 20 minutes. All mediae heated in Arnold before use to expel air from liquid mediae and to melt solid mediae. All were cooled to about 45°–50° C. before inoculating. Each tube was inoculated with 10 c.c. of water sample. Duplicates of each type of medium were inoculated. All liquid mediae were sealed with sterile white vaseline. Incubation at 37° C.

The iron compounds in the mediae served as indicators. By the bacterial reduction of the sulphates H_2S was generated which reacted with the iron salts to form ferrous sulphate, FeS. In the liquid mediae this appeared as a black precipitate often clinging to filamentous bacterial growths. In the solid media it colored the sperical colonies black.

All water samples carrying enough H_2S so that they might blacken the mediae by direct inorganic precipitation on inoculation were placed in a sterile vacuum dessicator and the H_2S removed by evacuation before the inoculations were made.

Of the nineteen waters collected from the southeastern Illinois fields, all but two showed sulphate-reducing bacteria. One of those giving negative results was a water free from H_2S. Eleven showed black precipitate or numerous black colonies at the end of the second or third day after inoculation when the first observations were made. After from six to ten days, the precipitates in the liquid mediae were profuse and the solid mediae were filled or nearly filled with a black growth of coalescing colonies.

Of the six waters collected from the Waterloo